DOCUMENT RESUME

ED 281 330 EC 192 424

AUTHOR Torello, Michael W.
TITLE The Measurement of Brain Electrical Activity and Its Significance to the Educator.
PUB DATE Apr 86
NOTE 14p.; Paper presented at the Annual Convention of the American Educational Research Association (San Francisco, CA, April 16-20, 1986).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Clinical Diagnosis; Diagnostic Tests; *Dyslexia; *Electroencephalography; Handicap Identification; *Learning Disabilities; Medical Evaluation; Neurological Organization

ABSTRACT

The article discusses the measurement of brain electrical activity and, in particular, the examination of electroencephalographic (EEG) data, as providing useful information in the diagnosis of dyslexia and other learning disabilities. Topographic imaging of EEG (TIE) is described as a procedure which provides functional data at comparatively low cost without invasive procedures or radiation exposure, and is considered potentially useful as a practical diagnostic tool. (JW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED281330

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

The Measurement of Brain Electrical Activity and its Significance to the Educator

Michael W. Torello, Ph.D.
Assistant Professor of Psychiatry
Director of the Psychiatric Neurophysiological Imaging Laboratory
The Ohio State University
Columbus, OH

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Michael W. Torello
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Introduction

There are a variety of medical imaging methods now available to clinicians and researchers which provide information about the brain. Some methods display structural data (e.g. computed tomography; magnetic resonance imaging), others provide functional information (e.g. regional cerebral blood flow; positron emission tomography; single proton emission computed tomography; topographic imaging of EEG). The relative merits of each technique are summaried in Table 1. Only magnetic resonance imaging and topographic imaging of EEG provide structural and functional data respectively but without invasive procedures or radiation exposure and at comparatively low cost.

Topographic Imaging of EEG (TIE)

Brain electrical activity is a complex pattern of varying

EC 192424

Paper presented at the Annual Convention of the American Educational Research Association (San Francisco, CA, April 16-20, 1986).

voltages and frequencies related to cellular responses to stimuli both within the environment and within the individual. The measurement of this electroencephalographic activity (EEG) was first made by Berger (1929/1969) who noted two types of waveforms, alpha and beta. Berger noticed that in a relaxed state, high amplitude relatively slow and synchronous trains of waves (alpha) were produced and he demonstrated that with "strenuous mental effort", low amplitude, relatively fast, and random activity (beta) was generated. Berger thought the suppression of alpha (increased beta) was due to the subject attending to a stimulus and noted that when the subject removed interest from this stimulus, slower waveforms appeared. In recent years other EEG waveforms have been identified (e.g., delta, theta, mu, etc.) and the presence or absence of these waveforms has been related to specific pathology. In general, greater amounts of higher frequencies are preferable to lower frequencies during problem-solving activities.

The most common way to measure human EEG is to paste 16 or more sensors to the scalp in specific locations which are above the areas of most interest on the surface of the brain. Very small voltages are detected by these sensors, amplified by a polygraph, and printed on paper before being visually interpreted by a clinician or researcher. Brain activity, reflecting the activity of aggregates of specialized cells (neurons), can be measured while the subject is relaxing or responding to external stimuli. This involves two basic strategies: (a) the analysis of

TABLE 1

COMPARISON OF VARIOUS NEURO-IMAGING TECHNIQUES

Type	Information Obtained	Invasive	Radiation	Frequent Multiple Scans Possible?	Comparative Cost
Computerized Axial Tomography (CT)	Structural	yes/no	yes	no	$
Magnetic Resonance Imaging (MR)	Structural	no	no	yes	$$$
Positron Emission Transaxial Tomography (PET)	Functional	yes	yes	no	$$$$$ $$$$$
Cerebral Blood Flow (CBF)	Functional	yes/no	yes	no	$$
Topographic Imaging of EEG (TIE)	Functional	no	no	yes	$
Single Photon Emission Computed Tomography (SPECT)	Functional	yes	yes	no	$$$

EEG by amount in a given frequency band (e.g., amount of alpha [8-12 Hz] activity) in order to determine which areas of the brain are more activited than others; and (b) the measurement of EEG during multiple presentations of a stimulus to a subject. This second strategy permits extraction of specific brain electrical events associated with a stimulus.

The repeated presentation of a stimulus makes it possible to average out all random EEG and enhance activity specifically related to a stimulus event of interest. This signal averaging technique thus removes the background noise and leaves the signal. An analogous situation occurs during a cocktail party when one is trying to detect the voice (signal) of an individual over the background chatter (noise). The EEG averaging technique was developed by Dawson (1951) but its full potential was never realized because of the complexity and amount of information that was necessary to evaluate.

The examination of EEG data has been extremely useful to the neurologist in the diagnosis of epilepsy. In the 1930s Gibbs and co-workers (Gibbs, Davis, & Lennox, 1935) discovered a characteristic electrical signature of epilepsy and there was hope of finding similar characteristic EEG patterns for learning disabilities, psychiatric illnesses, and Alzheimers Disease. However, neurologists were faced with the task of interpreting vast arrays of information, including the spatial and temporal relationship of multi-electrode patterns of ongoing brain activity, and determining whether these patterns were

significantly different from normal. They had to perform the heroic mental task of spectral analysis, spatial analysis, temporal summations, and statistical comparisons in order to make sense of the vast amount of data. (See Figure 1). This is not an easy task and requires years of training for even partial success. From the perspective of the neurologist, the EEG suffered from too much information to be realistically managed and evaluated.

EEG imaging techniques have been developed to deal with the problem of data reduction and interpretation. This new methodology can condense, summarize, and display on a color graphics monitor spectral, spatial, and temporal information of brain activity from up to 28 different scalp locations and can make statistical comparisons with a control group. The product of this automated data handing is a topographic map of electrical activity across the entire cerebral cortex (Duffy et al., 1979).

Brain activity from 28 sensors provides enough data to interpolate the activity at any given point on the scalp, generating a Topographic map of brain activity.
For evaluation of EEG data, the spatial distribution of activity in the classic delta, theta, alpha, and beta frequency bands can be displayed. Topographic imaging (TIE) displays are constructed from 28 channels of EEG data. Basically, the head is divided into a number of picture elements (pixels). A number is assigned to each pixel based upon the four nearest real values (actual electrode values) by linear interpolation. Each pixel is displayed in color where a particular color represents a range of

numerical values. Thus, a range of colors corresponds to varying microvolt values. It is possible to construct multiple images of EEG, recorded at different time points after repeated stimuli (e.g. visual or auditory) are presented to a subject. These images can be "cartooned" together and displayed as a dynamic moving image showing millisecond to millisecond changes of brain electrical activity which occur after a stimuli is presented.

These methods condense and summarize the spatial, temporal information obtained from multi-electrode recordings and assist the understanding of multiple dimensions of the EEG. Topographic imaging of EEG can extract more useful information from the vast array of EEG data, and has already proven its superiority over classical EEG analysis for the diagnosis of brain tumors. In a recent study (Duffy et al., 1979) accurate localizations of tumors were made using this technique on patients with normal "classical" EEG recordings. Topographic imaging of EEG has also been used successfully in psychiatric research, where specific EEG features have been found in groups of schizophrenic patients (Morihisa, et al., 1983; Morstyn et al., 1983 a,b; Torello et al., 1985; Torello et al., 1985 Torello and McCarley, 1986; McCarley et al., 1985). Thus, statistical difference maps have been created and specific electrophysiological features have been extracted, which for example, in a previous study, the P300 waveform, which is an event-related brain potential seen 300 msec following an unexpected stimulus, was measured. An t-SPM revealed a deficiency of middle and posterior temporal lobe amplitude of the P300

waveform in patients with chronic schizophrenia. This EEG feature correctly diagnosed 9/10 schizophrenics and 9/10 controls (Morstyn, et al., 1983).

Subsequently, the diagnostic validity of this EEG feature on a new sample, using a paradigm that controls for motivation and attention, has been examined. Ten new male schizophrenic subjects and ten new male controls with no history of psychiatric problems have been tested. For 7/10 of the subjects diagnosed as schizophrenic, these data show temporal deficiency of the P300 waveform in each subject that, on comparison with the new control group, corresponds well with the temporal region defined in the first study (Torello, et al., 1985).

This research exemplified the manner in which new technology (e.g., computer generated topographic mapping of EEG) can yield subtle biological markers of psychopathology. The sensitivity that this technique manifests suggests that topographic imaging of EEG may provide new and more useful diagnostic information.

This technique also has demonstrated that dyslexia is a neruophysiological problem with topographically specific brain areas of dysfunction. Dyslexia is a learning disability, specifically a reading disability, said to affect as many as 1 in 20 children (Rutter, 1978). It is not thought to be a disease with a unitary symptom, but rather a heterogeneous syndrome characterized in some patients by attentional deficits, hyperactivity, and soft neurological signs. There have been many reports of EEG abnormalities in dylexics (Torres & Ayers, 19698;

Hughes & Park, 1969; Hanley & Sklar, 1976; Sobotka & May, 1977; Symann-Louett, Gascon, Matsumiya, & Lombroso, 1977); however, these studies have not produced any reliable diagnostic features.

Duffy and colleagues (Duffy, Denckla, Bartels, & Sandini, 1980; Duffy, Denckla, Bartels, Sandini, & Keissling, 1980) studied a group of "dyslexia pure" subjects and their age-matched controls using the technique of topographic imaging of EEEG. A number of tasks (listening to music and speech, remembering abstract figures, paired associate learning, reading and relaxing with the eyes open or closed) were administered to these subjects and EEG was collected simultaneously. Striking differences were seen in patterns of EEG activity between the two groups. Several discrete brain areas were identified in the dyslexics as being significantly different from the norm. These areas included the medial frontal lobe on both sides of the brain, the left lateral frontal lobe, the left midtemporal lobe, the left posterior quandrant (including Wernicke's area), and the right posterior quadrant.

These brain regions correspond to areas classically associated with speech and reading. They are the areas which have been shown to differentiate, electrophysiologically, the brains of dyslexics and normals. Thus, the brain dysfunction that occurs in "pure dyslexia" is not localized to one area but appears to involve extensive systems involved in speech and reading.

Thes specific feature of brain activity that was always associated with the dyslexic subjects with greater alpha activity

in these regions. According to many studies, increases in alpha represent relative cortical inactivity (Gevins, Zeitlin, Doyle, Yingling, Schaffer, Callaway, & Yeager, 1979). Conversely, decreases in alpha have been shown to correspond to cortical activation (Davidson & Schwartz, 1977). The greater amount of alpha activity is evident in dyslexic subjects even when linguisitic tasks are not being performed and thus may represent a fundamental trait difference of lowered electrical activity in specific areas of dyslexic brains.

The diagnostic utility of this technique is evident. When numerical measures of brain electrical activity are used to develop diagnostic rules, they are shown to be 80 to 90 percent successful in classifying subjects as dyslexic or normal (Duffy, Denckla, Bartels, & Sandini, 1980; Duffy, Denckla, Bartels, Sandini, & Kiessling, 1980).

Implications

The fact that dyslexia is apparent to the clinician and educator, and can be verified using batteries of neuropsychological tests, might appear to make neurophysiological tests unnecessary. However, neurophysiological tests such as TIE have many advantages. The TIE method is non-invasive, objective, and can detect changes in brain function that may not be noticeable behaviorally at the present time. Aberrant brain electrical activity could alert parents and educators to a child at risk for learning disabilities before such disabilities manifest themselves as a change to school performance. If

learning disabilities can be recognized in advance and the child may be preventable. The typical feelings of inferiority experienced by the student as a result of school failure and associated behavioral problems in class may be avoided. Using TIE with classical educational and psychological assessments should increase the ability to accurately classify children at risk for school failure.

If additional studies can extend the initial findings and discover specific markers of dyslexia subtypes, the possibility exists for differential therapeutic strategies which are more efficacious depending on the subtype. Detection of abnormal EEGs may change the strategy of intervention for a child with a learning disability/behavioral problem. Instead of drug regimens or extensive psychotherapy, a more suitable cognitive rehabilitation program may be sought.

The potential for future research in this area is rich.

No single technique to study the problem of learning disabilities is adequate. Multiple views of the problem are needed and topographic imaging of EEG is providing a unique additional window into the function of the brain. The measurement and analysis of brain electrical activity will not only continue to shed new theoretical light on learning disabilities but will be a practical diagnostic tool for these dysfunctions. Although direct clinical application of this technique has not yet been realized, enthusiasm remains high.

REFERENCES

Berger H. On the electroencephalogram of man. Electroencephalography & Clinical Neurophysiology, 28, p.2825, 1969 (original work published 1929).

Davidson, R.J., & Schwartz, G.E. (1977). The influence of musical training on patterns of EEG asymmetry during musical and non-musical self-generation tasks. Psychophysiology, 14, 58-63.

Dawson GD. A summation technique for detecting small signals in a large irregular background. Journal of Physiology, 115, pp.2-3, 1951.

Duffy FH, Burchfiel JL and Lombroso CT. Brain Electrical Activity Mapping (BEAM): A Method for Extending the Clinical Utilizty of EEG and Evoked Potential Data. Annals of Neurology, Vol. 5, No. 4, pp. 309-321, April 1979.

Duffy FH, Denckla MB, Bartels PH and Sandini G. Dyslexia: Regional Differences in Brain Electrical Activity by Topographic Mapping. Annals of Neurology, Vol. 7, No. 5, pp. 412-420, May 1980.

Duffy FH, Denckla MB, Bartels PH and Sandini G. Dyslexia: Automated Diagnosis by Computerized Classification of Brain Electrical Activity. Annals of Neurology, Vol. 7, No. 5, p.421-428, May 1980.

Gevins, A.S., Zeitlin, G.M., Doyle, J.C., Yingling, C.D., Schaffer, R.E., Callaway, E., & Yeager, C.L. (1979). Electroencephalogram correlates of higher cortical functions, Science, 203, 665-668.

Gibbs FA, Davis H and Lennox WG. The electroencephalogram in epilepsy and in conditions of impaired consciousness. Archives of Neurology and Psychiatry, 34, pp. 1133-1148, 1935.

Hanley, J., & Sklar, B. (1976). Electroencephalographic correlates of developmental reading dyslexias: Computer analyses of recording from normal and dyslexic children. In G. Leisman (Ed.), Basic visual processes and learning disability (pp. 212-243). Springfield, IL: Charles C. Thomas.

Hughes, J.R., & Park, G.C. (1969). Electro-clinical correlation in dyslexic children. Electroencephalography and Clinical Neurophysiology, 26, 117-121.

McCarley RW, Torello MW, Shenton M and Duffy FH. The Topography of P300 and Spectral Energy in Schizophrenics and Normals. Abstract: The IV International Congress on Biological Psychiatry, Philadelphia, PA, September 1985.

Morihisa JM. Computerized Topographic Mapping of Electrophysiologic Data in Psychiatry. Psychiatric Annals, April, 1985.

Morstyn R, Duffy FH and McCarley RW. Altered P300 Topography in Schizophrenia. Arch. Gen. Psychiatry, Vol. 14, pp. 729-734, July 1983.

Morstyn R, Duffy FH and McCarley RW. Altered Topography of EEG Spectral Content in Schizophrenia. EEG and Clinical Neurophysiology, 56:263-271, 1983.

Rutter, M. (1978). Prevalence and types of dyslexia. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge (pp. 3-28). New York: Oxford University Press.

Sobotka, K.R., & May, J.G. (1977). Visual evoked potential and reaction time in normal and dyslexic children. Psychophysiology, 14, 18-24.

Symann-Louett, N., Gascon, G.G., Matsumiya, Y., & Lombroso, C.T. (1977). Waveform difference in visual evoked responses between normal and reading disabled children. Neurology, 27, 156-159.

Torello MW, Shenton ME, Cassens GP, Duffy FH and McCarley RW. Schizophrenia: P300 Temporal Lobe Deficit Confirmed. The American Psychiatric Association Annual Meeting, Dallas, Texas, 1985.

Torello MW and Duffy FH. Using Brain Electrical Activity to Diagnose Learning Disabilities. Theory into Practice, Vol. XXIV, No. 2, pp. 95-99, 1985.

Torello MW, and McCarley RW. The Use of Topograhic Mapping Techniques in Clinical Studies in Psychiatry. In, Topographic Mapping of Brain. ed. Duffy FH, Butterworth Publishers, Boston, 1986.

Torres, R., & Ayers, F.W. (1968). Evaluation of the electroencephalogram of dyslexic children. Electroencephalography and Clinical Neurophysiology, 24, 281-294.

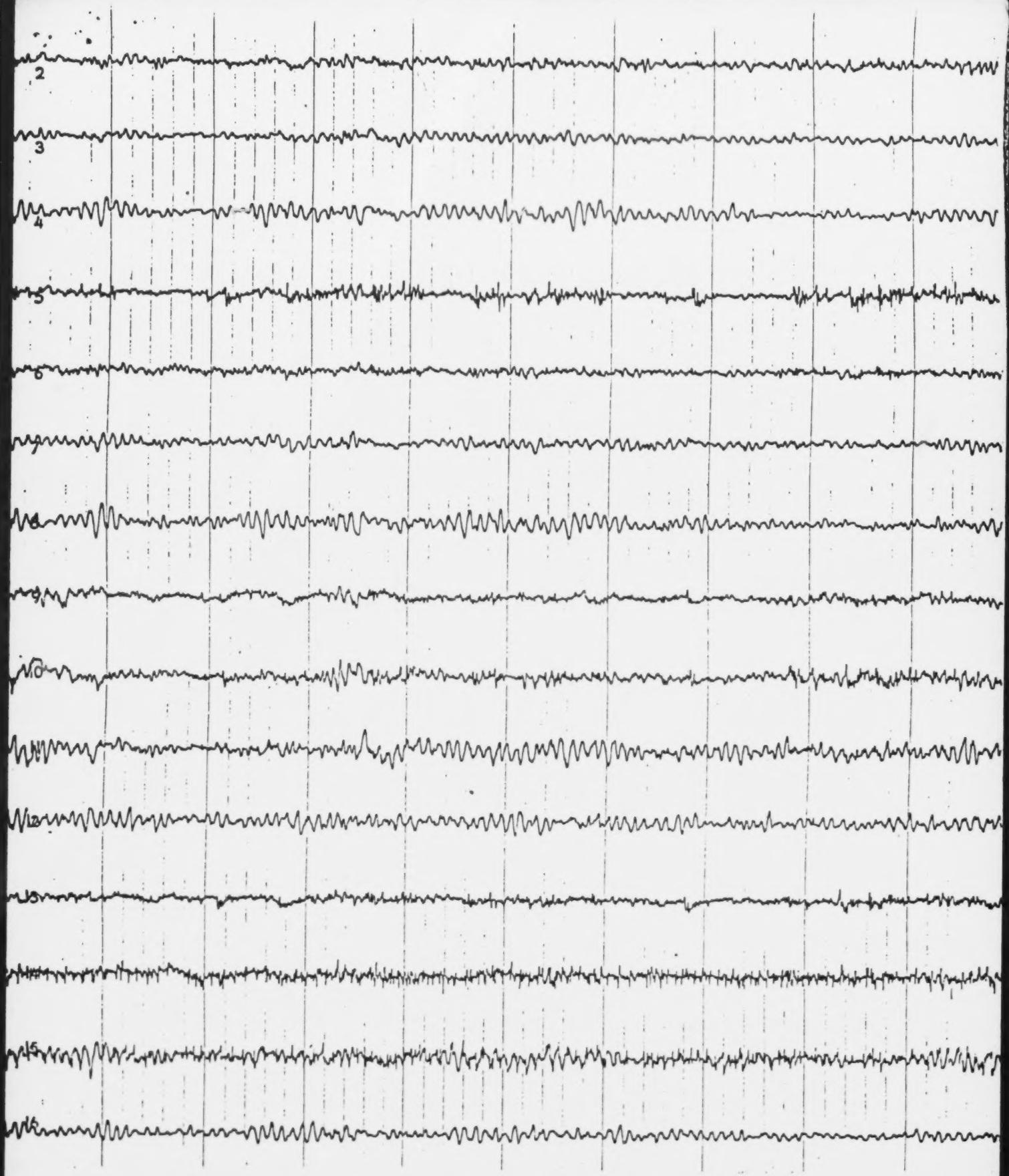

FIGURE 1. Traditional way of analyzing EEG involves the reviewing of multi-channel paper output. A typical multi-channel EEG recording is shown above.